TENNESSEE STATE UNIVERSITY

FINAL REPORT

PROJECT TITLE: MODERNIZATION OF ENGINEERING RESEARCH
INSTITIUTE AT TENNESSEE STATE UNIVERSITY

GRANT PERIOD: MARCH 1997 – MARCH 1999
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Final Report for Modernization of Engineering Research Institute (ERI) at Tennessee State University

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Annual Report for Modernization of ERI

1. Executive Summary

Funding from 1997 DoD HBCU/MI infrastructure support for educational instrumentation provided support for Tennessee State University to modernize its Engineering Research Institute (ERI). State of the art equipment with associated software was purchased to enhance the research capabilities of image processing, concurrent manufacturing, networking and communication and robotics and machine vision laboratories.

The impact of this equipment led to completion of 13 undergraduate senior capstone design projects and 14 masters' theses during 1999-2000. In addition 7 new graduate level courses were established to enrich the electrical and mechanical engineering curriculum and enhance the career opportunities of our students. The equipment funds were leveraged to obtain two new grants in robotics from NASA Ames and JPL totaling $631,000, and a contract from BWXT-Y12 security complex for $198,000. Based on enhanced research capabilities Tennessee Board of Regents approved Ph.D. degree program in Computer and Information Systems Engineering (CISE) in the College of engineering, Technology and Computer Science.

2. Background

In Spring 1983 the Tennessee Board of Regents established an Engineering Research Institute (ERI) to serve as a research arm of the College of Engineering and Technology. ERI provides a conducive atmosphere for the faculty to seek research partnerships with academia, industry and federal laboratories and submit interdisciplinary/multi-team projects. ERI has found a niche that led to a focused research resulting in the establishment of the Center for Neural Engineering (CNE) in 1992 and a large number of publications and presentations of both faculty and students at national and international conferences. The following summarizes the goal and objectives of the ERI.

1. Provide capability to win more STTR awards.
2. Increase the number of collaborative research projects with federal laboratories, industries, and other academic Institutions.
3. Provide summer experiences for students in industries and national laboratories.
4. Increase the pool of minority and under-represented students in critical technologies of interest to DoD.
5. Equip the Center with the cutting edge technology instruments.
6. Provide an environment for faculty to spend sabbatical leave at CNE.
7. Be a conduit for technology transfer.

Primary focused research has emerged in the areas of signal processing, image processing, biologically motivated neural networks, controls and robotics in the Electrical and Computer Engineering Department: probabilistic design methodologies, tribology, computational fluid dynamics and computer integrated manufacturing in Mechanical Engineering; transportation safety and environmental engineering in Civil Engineering. The sponsored research activity has grown from one research project in 1981 to sixteen and the federal funding level has increased from less than $50.000 to $1.6 million, a

remarkable total for a school of our size. ERI has provided research opportunities for both minority and female undergraduate and graduate students in meeting the nation's manpower needs in critical technologies. During Fall 1995 about 30 undergraduate and 27 graduate students assisted 18 faculty in research activities.

The ERI is continually seeking ways to improve quality of its engineering programs and serve better educational needs of students and advance its competitiveness edge with other universities in the United States. In pursue of this goal, ERI identified four key research laboratories which needed improvements including: Image Processing Laboratory, Concurrent Manufacturing Laboratory, Networking and Communication Laboratory, and Robotics and Machine Vision Laboratory. Tennessee State University received an award of $389,356 from the office of Naval Research under the FY 97 DoD HBCU/MI Infrastructure Support for Educational Instrumentation. The grant number is N00014-97-1-0538 and the grant period was 15 March 1997 through 14 March 1999. Dr. Mohan J. Malkani Associate Dean of Engineering and Director of Engineering Research Institute and Director of Center for Neural Engineering was PI on this grant titled "Modernization of Engineering Research Institute."

This proposal had four components including (1) Development of Image Processing Laboratory, (2) Enhancement of Concurrent Manufacturing Laboratory, (3) Development of Networking and Communication Facility, and (4) Enhancement of the Robotics and Machine Vision laboratory. The proposal presented goals and objectives of each research laboratory. It discussed needs of each research and development component and explained our strategic plan for their improvement and implementation. Each activity was identified with a Principle Investigator who would be fully responsible for achievement of goals and objectives of his proposed activity.

The College of Engineering, Technology and Computer Science had strong commitment in fulfilling the goals and objectives of the proposed activity and provided adequate resources as a matching support for this project. The matching support was provided from several channels including: granting five faculty release-times during academic year, providing assistantships for graduate students, providing technical staffs, and accommodating necessary research and development supports for implementation, service and maintenance of the proposed research laboratories

The goals and accomplishments of each of the proposed laboratory enhancement are stated below:

3. IMAGE PROCESSING LABORATORY
Faculty in Charge: Dr. Mohammed Bodruzzaman, Professor of Electrical and Computer Engineering

3.1 The objectives of the image processing laboratory were the following:

1. Develop wavelet transfer-based image analysis tool that allow improved and enhanced multiscale information in 2D and/or 3D and extract more simplified feature set of signal invariance.

2. Develop neural network-based decision-theoretic methods of recognition that offer improve techniques for learning and generalization and classification based on the features extracted using the Wavelet transform and other modem signal/image processing techniques.

3. Develop well-prepared research laboratory for hands-on experience and develop senior capstone design projects and Masters Theses for undergraduate and graduate students respectively.

3.2 ACCOMPLISHMENTS

Developed Image Processing Laboratory with the purchase of dual processor based image processing system, and associates software. Developed, and offered a graduate course, EE 523- Digital Image Processing.

Using this laboratory as a base we have developed a concentration in Bio-medical Engineering in the Master of Engineering Degree Program. Currently we have four students in Biomedical Engineering program and this number will increase to 9 in fall 2003 semester. We are also using the laboratory this summer to train 8 undergraduate and graduate minority students in biomedical engineering under the Summer Applied Research Program funded by NSF. The NSF grant provides funds to build research capacity and increase doctoral success for underrepresented minorities.

We leveraged this laboratory to secure additional funds from FY99 DoD HBCU/MI Infrastructure Instrumentation Grant of $81,000 to purchase Biopack bio-medical equipment to enhance the image processing laboratory, thus making effective use of DoD instrumentation grants.

4. CONCURRENT MANUFACTURING LABORATORY (CME)
Faculty in Charge: Dr. Amir Shirkhodaie, Associate Professor of Mechanical and Manufacturing Engineering
4.1 The objectives of this laboratory were the following:

1. Integrate CME laboratory to allow for conducting effective factory teaching and conducting research/development on advanced topic in Life Cycle Engineering and Predictive and Preventive Maintenance.
2. Develop high performance computing facility for CAD/CAM intensive applications.
3. Develop rapid prototyping capability in CAD/CAM laboratory for students training purposes.

4. Develop data acquisitions capability for conducting experimental research in vibration laboratory.

The goal was to develop a comprehensive laboratory where our students can become familiarized with principles of CAD/CAM/CAE/CIM and rapid-prototyping through hands-on practices with manufacturing equipment and computing instruments. This required providing them with more high performance computers and appropriate software and tools for their training. Based on a thorough assessment of our laboratory instruments and our offered programs, we identified that our laboratory needed six more CAD workstations, one rapid prototyping 3D plotter, two low-end Silicon Graphics workstations, and appropriate software and hardware for establishing a complete computer-integrated manufacturing network. Furthermore, in support of vibration laboratory, we needed at least four PC workstations equipped with multi-channel data acquisition systems, signal analyzers, and vibrational signal pickups. The accomplishments of this laboratory are listed next.

4.2 ACCOMPLISHMENTS

We leveraged these funds to secure additional funding of $170,000 through DURIP in collaboration with Applied Research Laboratory of Penn State University (ARL/PSU) and have developed a test bed in Ball –Bearing Health Monitoring System with LabView data acquisition systems for on-line real time fault diagnosis. We also have FDS Stratasys rapid prototyping machine, and with the purchase of CAD workstations with associated software, we have now implemented a computer-integrated manufacturing network.

We have developed three graduate level courses in manufacturing concentration in the Master of Engineering program. They are 1) ME 561-Computer-Aided Design and Manufacturing, 2) ME 564-Manufacturing Modeling and Simulation and 3) ME 565-Predictive and Preventive Maintenance.

We have also leveraged these facilities to secure a two years contract of $198,000 from BWXT Y-12 Security Complex in Oak Ridge, Tennessee titled "Application of Fuzzy Logic Data Analysis to Coordinate Measuring Machine Uncertainty."

5.0 Networking and Communication Facility
Faculty in Charge: Dr. Geoffery Yuen, Post-Doctoral Research Associate

5.1 The objective was to provide internet networking and hardware support for collaborative educational and research projects

5.2 ACCOMPLISHMENTS

Dr. Yuen has been developing a biologically inspired neural network navigation algorithm with a neuroscientist in Ohio (Northeastern Ohio University College of Medicine, Rootstown, OH; Professor Timothy Teyler) as well as a computer scientist in Louisiana (University of Southwestern Louisiana, Lafayette. LA; Professor Anthony Maida). While Professor Teyler provides some of the needed experimental data,

Professor Maida. Provides software development expertise for the simulator. Due to the large and complex data/graphics files as well as the extensive interaction and collaboration required, screen sharing and phone conferencing are used frequently. A higher speed ISDN connection greatly improved the support for this project.

We purchased a parallel DPS system for performing real-time neural networks computations for controlling a mobile robot (PC-based, Transtech DBMP 412 with eight Texas Instrument C40s, 50 Mflops/Processor). This system was originally designed for use with image processing and some neural networks algorithms developed here at the Center for Neural Engineering that are being ported to this board. We hope to make this resource available for research and teaching through the internet. In particular, with the addition of a high speed analog-to-digital frame grabber board and camera, the same system can be used to demonstrate and test various image classification algorithms in real-time due to the high speed achievable (60 fps VGA, - 500 Mflops).

We also received a five year $400,000 grant from NSF in Tele-robotics titled "Towards Consumer Telepresence" jointly with Caltech, whereby the two institutions geographically 1700 miles apart can control each other's mobile robot through internet. Caltech's robot was vision driven whereas TSU's robot was sonar division. The combination of both algorithms has provided better image processing capability of the environment for navigation and path planning.

We installed both commercial T1 as well as ISDN service to improve existing internet access rates. A T1 connection was judged to be prohibitively expensive while an ISDN connection would provide sufficient bandwidth for video conferencing as well as almost real-time remote control capabilities to remote locations. However, the access needed to be network-capable because otherwise only one client could participate at one time and ruling out its use in a group conference, classroom/teaching setting. This implied the installation of a dedicated leased ISDN line to a small LAN with about 10-20 clients (as would be needed for a classroom use). The recommended minimal bandwidth requirement for video conferencing for a single client was 64Kbps. A 128K ISDN service with compression that could support two simultaneous sessions or a group conferencing session was installed.

6. Robotics and Machine Vision laboratory
Professor in Charge: Dr. Saleh Zein-Sabatto, Professor of Electrical and Computer Engineering
6.1 The objectives of this laboratory were three folds:

1. To acquire hardware equipment and software to enhance and strengthen the research activities conducted in the department of electrical and computer engineering in the area of intelligent control systems and machines.
2. To acquire hardware equipment and software to develop an undergraduate new course in the area of vision systems, and two graduate courses in the area of active

vision and machine learning. The equipment is expected to improve the quality of classroom teaching and provide students with hand-on experience.

3. To attract and generate more funded research from ONR, ARL, and NASA to support the research effort at TSU and contribute to the advances in the area of intelligent control systems and machines

6.2 ACCOMPLISHMENTS

We have purchased two Arric mobile robots and pan-tilt for B12 mobile robot. We have also equipped the robot with wireless communication, and have improved the capability of our robotics laboratory with the acquisition of machine vision systems, robot arm, and robot gripper to develop capability in active vision based intelligent manufacturing. We have also purchased Pioneer mobile robots and have fitted them with Tilt/Pan vision systems.

We leveraged these funds to secure 3-year grant of about $431,000 from NASA Ames Research Center in "Embodiment of Intelligent Behavior on Robots."

We recently received additional 3 year $300,000 grant from JPL-NASA titled "Visual Telerobotic Task Planning of Cooperative Robots Based on Soft Computing." The idea is to simulate a human-machine interface for virtual environment to control robots on Mars using AI technologies.

We have also developed three graduate level courses in CISE concentration 1)CISE 620- Introduction to Computational Intelligence, 2)CISE 640- Fundamentals of Robotics in Manufacturing, and 3) CISE 742- Robotics and Machine Intelligence in Manufacturing. Thus through the development of this laboratory we also enhanced the research capabilities of the Center for Neural engineering.

7.0 IMPACT ON STUDENT TRAINING

The modernization of Engineering Research Institute through FY 97 DoD grant has resulted in many undergraduate senior capstone design projects and graduate theses. They are listed below for the years 1999 and 2000.

7.1 Undergraduate Senior Capstone Design Projects

1. Gold, Kimberly, "Design of a Navigation Algorithm for Mobile Robots," May 1999, Advisor- Dr. Saleh Zein-Sabatto.
2. Overton, Monica, "Design of an Intelligent Recognition System for Automatic Speed Limit Control," May 1999, Advisor- Dr. Saleh Zein-Sabatto.
3. Bryant, Geralyn, "Design of an Intelligent Flight Controller for High Performance Aircraft Pitch Control," December 1999, Advisor- Dr. Saleh Zein-Sabatto.
4. Miles, Shannon," Design of a Data Acquisition System Using a Microcontroller," December 1999, Advisor- Dr. Saleh Zein- Sabatto.

5. Benjelloun, Younes, "Design of Software for Map Building of Unknown Environment Using Mobile Robot," May 2000, Advisor- Dr. Saleh Zein-Sabatto.
6. McNeal, McKenzie, "The Scholarship Information System," May 2000, Advisor- Dr. S.S. Devgan.
7. Marshall, Gomez, "Design of an On-Line Database for The Engineering Concepts Institute," May 2000, Advisor- Dr. S.S. Devgan.
8. Walker, Laron, "Design of an Intelligent Navigation Algorithm for a Mobile Robot Via Internet," May 2000, Advisor- Dr. Saleh Zein- Sabatto.
9. Clayton, Kriste, "Design of an Identification System Using DTMF Circuitry," December 2000, Advisor- Dr. Mohammad Bodruzzaman.
10. Albriotton Nathan, "Design of a Beam Diagnostic system for a Free Electron Laser," December 2000, Advisor- Dr. Saleh Zein-Sabatto.
11. Gay, Leslie, "Design of a Diagnostic System for Gearteeth Fault Detection Using Image Processing Techniques," December 2000, Advisor- Dr. Saleh Zein-Sabatto.
12. Slaughter, Annie, "Development of Demobot 1: A Practical Application for ENGR 100L," December 2000, Advisor- Dr. Saleh Zein-Sabatto.
13. Smith, Alexander," Design of an Object Detection System for Automobiles," December 2000, Advisor- Dr. Mebenin Awipi.

7.2 Master's Thesis
1. Beane, Carlos, "Design of a Frank Lead Converter for the Localization of Cardiac Arrhythmia," August 1999, Advisor- Dr. Mohammad Bodruzzaman.
2. Phothimant, "A Comparison Technique Using Wavelet Transform for Wideband Audio Signals," May 1999, Advisor- Dr. Mohammad Bodruzzaman.
3. Ramamurthy, Varadarajan, "Data Fusion for Intelligent Navigation of Mobile Robots," May 1999, Advisors-Dr. Mohammad Bodruzzaman and Dr. Geoffrey Yuen.
4. Sheshadhari, Darakanath, "Implementation of Navigational Neural Networks on a Parallel DSP Board," May 1999, Advisors-Dr. Mohammad Bodruzzaman and Dr. Geoffrey Yuen.
5. Dubeck, John D., "Rolling Element Bearing Fault Diagnosis Using Physics-Based Finite Element Modeling Techniques," August 1999, Advisor- Dr. Amir Shirkhodaie.
6. Drews, Steven, "Development of an Intelligent Navigation Algorithm for Mobile Robot Using Fuzzy Logic Technique," August 1999, Advisor- Dr. Saleh Zein-Sabatto.
7. Pari, Santhanakrishnan, "Rule-Based Fuzzy Logic Assisted Diagnostic Expert System for Rotatory Machinery," August 1999, Advisor- Dr. Amir Shirkhodaie.
8. Venu, Challagolla, "Target Recognition And Tracking Of Mobile Robotic Vehicles Using Image Processing and Neural Network Techniques," August 1999, Advisor- Dr. Amir Shirkhodaie.
9. Aderogba, Samuel A., "Navigation And Visual-Terrain Tracking For Mobile Robots," August 2000, Advisor- Dr. Amir Shirkhodaie.
10. Patkar, Abhijit C., "A fuzzy Logic Controller for the Navigation of a Group of Mobile Robots," August 2000, Advisor- Dr. Amir Shirkhodaie.

11. Mansour, Mohammad A., "Navigational Behavior Algorithms for Multi- Agent Intelligent Tandem Mobile Robots," August 2000, Advisor- Dr. Amir Shirkhodaie.

12. Heard, Kemba N., "Physics-Based Rotor Dynamics Analysis & Failure Prediction Using Finite Element Modeling Techniques," December 2000, Advisor- Dr. Amir Shirkhodaie.

13. Heard, Kemba N., "Physics-Based Rotor Dynamics Analysis & Failure Prediction Using Finite Element Modeling Techniques, "December 2000, Advisor- Dr. Amir Shirkhodaie.

14. Nadaye, Cheikhou O., "Development Of A Graphical Interface Simulation Package For Cam And CNC Application Using FM Cell," December 2000, Advisor- Dr. Amir Shirkhodaie.

8.0 SPIN OFF---PH.D. IN CISE

As a spin-off due to the purchase of state of the art equipment coupled with enhanced research activity, the Tennessee State Board of Regents approved a Ph.D. degree program in Computer and Information Systems (CISE). The degree is housed in College of Engineering, Technology and Computer Science. CISE has a core in Systems Engineering and three concentrations in 1) Computer and Communication Networks, 2) Controls and Signal Processing and 3) Robotics and Computer Integrated Manufacturing. The Ph.D.-CISE degree derives its strength from computer science, computer engineering, electrical engineering, mechanical engineering and manufacturing engineering disciplines.

This additional Ph.D. brings Tennessee State University to Carnegie level II University. The university now offers six doctoral degrees in public administration, administration and supervision, curriculum and instruction, psychology, biological sciences, and computer and information systems engineering.

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14. ABSTRACT Funding from 1997 DoD HBCU/MI infrastructure support for educational instrumentation provided support for Tennessee State University to modernize its Engineering Research Institute (ERI) to enhance the research capabilities of image processing, concurrent manufacturing, networking and communication and robotics and machine vision laboratories. The impact of this equipment led to completion of 13 undergraduate senior capstone design projects and 14 masters' theses during 1999-2000. In addition 7 new graduate level courses were established to enrich the electrical and mechanical engineering curriculum and enhance the career opportunities of our students. The equipment funds were leveraged to obtain two new grants in robotics from NASA Ames and JPL totaling $631,000, and a contract from Oak Ridge for $198,000. Based on enhanced research capabilities Tennessee Board of Regents approved Ph.D. degree program in Computer and Information Systems Engineering (CISE).

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